An Empirical Application of Industrial Organization Theory to the Study of Vertical Coordination

by

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Vertical coordination is a concept whose time has almost come. That it has almost come is evidenced by the emerging body of literature addressing this phenomenon [see Marion, 1976A, for example]. That it has not yet arrived is evidenced by a lack of agreement on what is meant by vertical coordination. Some define it as the method or the process by which the activities at tangent vertical stages in a production-marketing system are harmonized, orchestrated or otherwise coordinated. Others define it as how well such coordination occurs. That is, some suggest that vertical coordination is a process; others suggest it is the result of a process.

Mighell and Hoofnagle have perhaps the first word on what is vertical coordination. They define it as a process: "...all the ways of harmonizing the successive vertical steps, or stages, of production and marketing." Viewed this way, there is a remarkable conceptual similarity to competitive market behavior. The difference: competitive behavior refers to the actions of rivals, each seeking to be selected over their rivals by someone on the other side of the market [Arthur, 1972]. Vertical coordination refers to the actions or activities of dependents -- suppliers and supplyees, sellers and buyers -- each seeking a complimentary or cooperative arrangement with each other.

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The outcome or the results of the process of vertical coordination can be viewed as coordinative performance, much as market performance is the outcome of competitive market behavior. Both are roughly synonymous with economic performance as measured by such things as operational efficiency, progressiveness, stability, growth, equity and allocative accuracy.

Both Marion [1976B] and Henderson [1975A, 1975B] have suggested that the structure-conduct-performance paradigm of industrial organization theory might be applicable to studies of vertical coordination. Perhaps, certain structural characteristics can be identified which are related to the kinds of coordinating behavior engaged by persons in tangent vertically arrayed stages in a production-marketing system, just as market structure is related to competitive behavior. Likewise, different performance results might be associated with different coordinating activites. We set out to test the applicability of this concept, of the idea that industrial organization theory can be expanded and modified to provide a basic framework within which vertical coordination can be examined as to its causes and consequences. This paper reports on that effort.

The Theoretical Model

Hypothetically, there are a large number of structural variables, types of coordinating behavior and dimensions of performance relevant to vertical coordination. Among the structural conditions or variables which have been suggested by Marion and by Henderson are the number of enterprises in vertically tangent stages, the relative size of enterprises in these stages, the number of parallel channels through which vertically tangent stages can interface (such as various market channels, contracting opportunities, and so on), the perishability of products, the homogeneity or heterogeneity of products, the spatial distribution of enterprises at vertically tangent stages, and the frequency of transactions between such enterprises.

Conceptually, types of coordinating behavior can vary as widely as does competitive behavior. In industrial organization theory, competitive activities are measured in terms of variables such as product strategies, pricing behavior, advertising and promotion, research and innovation and legal tactics [Scherer, 1971], and range on a continuum defined by perfectly competitive behavior at one end and perfectly monopolistic behavior at the other. In between are behaviors loosely categorized under headings such as monopolistically competitive and several categories of oligopolistic. Likewise, coordinating behavior can be specified in terms of variables such as type of exchange or inter-stage transaction, process of determining terms of exchange, and the extent to which a long-term agreement over various terms of exchange is used [Marion, 1976B].

Conceptually, just as its possible to array types of competitive behavior on a continuum ranging from perfect competition to perfect monopoly, it is also possible to array types of coordinating behavior on a continuum ranging from spot market transactions at one extreme to vertical integration (common ownership of two or more tangent vertical stages) at the other extreme. Richardson has illustrated that the difference between these extremes is the difference between coordination which is securred through conscious direction within firms (vertical integration) and that which is left to the spontaneous working of the invisible hand (spot market transaction). In between is an array of transaction practices in which interstage coordination is achieved with an increasing amount of spontaneity and a decreasing amount of conscious direction. This array includes established trading practices, various marketing arrangements such as auction markets and private treaties, use of market agents such as commission firms, and various types of subcontracting, contracting, and joint ventures.

Richardson points out that, what is varying along this continuum is the extent to which parties operating vertically arrayed enterprises accept obligation

and thus provide assurance to each other with respect to their future conduct. With spot market transactions there is no advanced commitment. As we move along the continuum, the mutual obligation of two vertically-related enterprises or trading partners to each other increases until they come under common control at the vertical integration extreme.

Regarding performance measures, it is conceptually possible to include any dimension of economic performance in a study of industry structure and behavior. Realistically such study is limited to those dimensions which are measurable. Marion [1976B] has suggested that the performance dimensions most likely to be affected by various coordinating activities include allocative accuracy (or the extent to which the output of one stage of production aligns with the input needs of the next stage), stability of output, prices and profits, operational efficiency, waste and spoilation, and the equity with which risks and returns are shared among enterprises at various stages.

The Research Setting

Our test of the applicability of the structure-conduct-performance paradigm for studying vertical coordination was combined with an ongoing effort to more accurately describe and understand vertical coordination in the cow/calf-feedlot segment of the beef subsector. Therefore, our analysis was limited to one industry - feeder cattle, and essentially three stages of production: cow/calf enterprises, growing enterprises and feedlots. Additionally, as the new use of a conceptual model requires unique specification of variables, considerable primary data had to be collected. To keep the task manageable and within a narrow budget, primary data collection was limited to the state of Ohio.

Data used in our analysis were collected through a mail questionnaire. The questionnaire was designed to gain mirror-image responses from operators of cow/calf enterprises as suppliers/sellers, from feeder cattle growers as both

buyers and sellers and from feedlot operators as buyers. The mirror-image technique allowed paired comparisons among sets of traders with common output-input relationships. Questionnaires were mailed in October, 1975 to 4500 names randomly selected from lists of cattle producers maintained by extension agents in each of Ohio's 88 counties. By December, 1975, 948 returns were received, upon which our analysis is based.

The Model Tested

In this study, basic structural variables were limited, either by intent or by our ability to collect useable data, to (1) size of enterprises, (2) perceived product perishability, (3) perceived product heterogeneity and (4) spatial distribution of vertically-arrayed enterprises. These were measured as follows: enterprise size was specified as a continuous variable in terms of the number of feeder cattle produced for cow/calf enterprises, the number grazed for growing operations and the number placed in feedlots for feeding enterprises. Product perishability was treated as a discrete variable based upon perceived shrink and death loss of feeder cattle during inter-enterprise transfer. These ranged from zero to 12 percent for shrink and from zero to 5 percent for death loss. Perceived heterogeneity was considered a discrete variable based upon whether or not respondents indicated a preference for feeder cattle of a specific weight and/or quality grade. Spatial distribution was measured based upon the reported distance between enterprises with direct output-input connections, for example, the distance between a feeder cattle enterprise and a feedlot where those cattle were fed.

We specified coordinating practices in the feeder cattle industry along the theoretical continuum, based upon an index value associated with the extent to which users of various coordinating practices perceived an advance obligation to their trading partner. For a spot transaction, we assigned a value of zero and

for vertical integration, a value of 100. Based upon our survey of Onio cattlemen we found six distinct types of coordinating practices: use of (1) weekly livestock auctions, (2) special feeder cattle auctions, (3) state-approved graded feeder cattle auctions, (4) order buyers, (5) private treaties, and (6) vertical integration. The first four represent various types of established trading relationships while private treaties represent various types of subcontracting and contracting situations.

Unfortunately, we did not have adequate data to partition private treaties into more specific categories such as established direct trading relationships, marketing contracts, production contracts and so on which could be more precisely tied to degrees of advance obligation. Contracts are rarely used in this industry, thus we did not have as much specific detail on coordinating practices in our experiment as would be desirable for thorough testing of this conceptual model.

An index value was then calculated for each type of coordinating behavior based upon the percent of respondents using a particular practice who reported a specific advance commitment to another vertically positioned enterprise. The resulting values are shown in Table 1.

Table 1. Indices of Advance Obligation Associated with Selected Coordinating Practices in the Ohio Feeder Cattle Industry, 1975.

Coordinating Practice	Index
Weekly Livestock Auction	14.0
Special Feeder Cattle Auction	17.5
Approved Graded Feeder Cattle Auction	25.0
Order Buyers	43.0
Private Treaties	52.0
Vertical Integration	100.0

Source: Nyanteng, p. 171.

These index values resulted in the ordering of the coordinating practices in the same order that we expected based upon a priori knowledge of these practices, thus we felt they were useable. Nonetheless, we have two concerns with these values. First, we believed a priori that weekly livestock auctions were essentially spot market transactions, that very little if any advance obligation exists and therefore should have an index value near zero. Thus, the calculated value of 14.0 seems high. Perhaps, the respondents were reflecting advance obligation to the operator of a market rather than to an enterprise at another stage of production. Secondly, the wide difference between the values for private treaties and for vertical integration, caused by our inability to more precisely specify various types of contracting behavior, detracts from the detail which is desirable in the upper half of the index range and is regrettable. Improved specification is surely possible.

We attempted to measure performance in terms of efficiency and allocative accuracy. Operational efficiency was specified in terms of both coordinating (transaction) costs and waste, and allocative accuracy in terms of both quantity alignment and quality alignment between enterprises producing and those using feeder cattle. We were unsuccessful in gathering consistent and reliable data on coordinating costs, thus were limited to a partial measurement of operational efficiency in terms of product loss (physiological costs). This was measured by cattle death and weight loss during inter-enterprise transfer. We used two measures to estimate allocative accuracy: (1) the extent to which operators of enterprises using feeder cattle as inputs (growing and feeding) indicated that they could not procure an adequate supply of feeder cattle of the type and quality desired, and (2) the extent to which quality perceptions of feeder cattle held by producers and users were inconsistent with each other.

The quality perception measure was based upon Purcell's study where he reported "significant differences of opinion between feeder and producer groups as to what characteristics give value to a feeder animal" [p. 67]. He used a mirror image approach with written and pictorial quality descriptions of feeder cattle submitted to producers and feeders in Oklahoma. We used the same technique, hypothesizing that there were differences in the deviations between producers and users quality perceptions, depending upon the type of coordinating behavior engaged. That is, we expected to find less disagreement between producers and users over what constitutes quality in feeder cattle among those involved in private treaties or vertical integration, compared to those who coordinate through spot markets.

The Results

A linear regression model of the form:

$$Y = f(X_1, X_2, X_3, X_4)$$

was used to analyze the relationship between coordinating behavior and basic structural conditions, where:

Y = the index value of the coordinating practice used

X_1 = enterprise size

X_2 = perceived product perishability

X_3 = perceived product heterogeneity

X_4 = spatial distribution of vertically-arrayed enterprises.

Variables X_2, X_3 and X_4 were specified as dummy variables in the model while Y and X_1 were included as continuous variables. Step-wise multiple regression was used to fit the equation. The results are summarized in Table 2.

Table 2. Results of Stepwise Linear Regression of Vertical Coordination Against Selected Measures of Basic Structural Conditions

Independent Variable	Regression Coefficient	Standard Deviation	Cummulative R^2
Constant	40.1447	3.9952	
Spatial Distribution	13.7062**	5.6435	0.0644
Enterprise Size	0.0115**	0.0047	0.1057
Perceived Heterogeneity			0.1283
Weight Preference	-6.8472**	3.5910	
Quality Preference	0.6644	2.1689	
Perceived Perishability			0.1512
Death Loss	-4.2868*	2.9254	
Shrink	3.2761	2.6974	

** Significant at the 95 percent Confidence Level.
* Significant at the 90 percent Confidence Level.

Both spatial distribution and enterprise size were found to be structural variables related to the type of coordinating behavior with a statistical significance exceeding the 95 percent level of confidence. Additionally, one partial measure of product heterogeneity, weight preference, was also related with a confidence exceeding 95 percent while one partial measure of product perishability, death loss, was significantly related to coordinating behavior with greater than 90 percent confidence. The other measures of perishability and heterogeneity, however, were not significant at the 90 percent level.

Spatial distribution, or the geographical distance between vertically tangent enterprises, was the most important explanatory variable examined, and was positively correlated with about 6.5 percent of the variation in the index values associated with coordinating behavior. That is, as distance between these enterprises increases, there is a relatively small but significant increase in

the advance coordinative obligation of vertically tangent enterprises to each other. Enterprise size was the second most important explanatory variable, positively associated with about four percent of the variation in coordinating behavior. That is, as enterprise size increases, so does advance obligation. Product heterogeneity and perishability were each associated with about 2.3 percent of the variation in coordinating behavior. In total, just over 15 percent of the variability in the index value of coordinating behavior was explained by the structural conditions examined. While this represents a statistically significant difference from zero correlation at the 95 percent level of confidence, the model represents low explanatory power and is clearly underspecified.

We had notably less success in dealing with performance, largely because we did not find much variation across the industry in Ohio in the magnitude of the performance parameters measured. Evaluation of operational efficiency was limited because of our lack of data on transaction and coordination costs. Additionally, we found little actual variation in physiological costs, measured in terms of shrink and death. For example, in 89 percent of the interstage transfers of feeder cattle examined in Ohio, no death loss was reported. In over 90 percent of such transactions shrinkage was reported to be 5 percent or less. Thus, there was insufficient variation in this measure of performance to determine a statistical association between it and coordinating behavior. Nonetheless, respondents did report sharply reduced shrinkage, death loss and transaction costs when using contracts as opposed to no contracting in the coordinating process. However, we did not have enough observations on contracting to allow testing for statistical association.

Also, we did not find much variation in our measures of allocative accuracy. About 90 percent of the feeder cattle users reported no difficulty in procuring adequate supplies. And, contrary to Purcell's findings, we found no statisti-

cally significant differences in the perceptions of producers and users with regard to what characteristics give value to feeder cattle, thus we could not correlate such differences with various coordinating practices. There are several plausable explanations for the inconsistency of our findings with those of Purcell: (1) there are differences between Ohio and Oklahoma cattlemen, (2) there are changes in quality perceptions of feeder cattle by cattlemen over time; our findings were based upon a 1975 survey while Purcell's were based upon a survey occurring sometime prior to 1973, and/or (3) one or both studies contain errors of specification or measurement. While the similarity of technique (mirror image opinions of pictorial and written quality descriptions) argues against the latter explanation, differences in sample size (46 in Purcell's study, 948 in ours) may partially offset that argument.

While little concrete evidence was uncovered concerning interrelationships between vertical coordination and performance, this does not mean, per se, that such linkages don't exist. Rather, the lack of significant relationships in our study stemmed largely from the small amount of variation discovered in the performance measures used. Improved measurements of an expanded array of performance dimensions are clearly in order.

Limitations

From the outset there were two major limitations to the usefulness of any conclusions which could be drawn from this study: first, the model was tested in a single industry rather than in a multiple industry situation. The latter should yield greater variability in the parameters and thus reveal greater insights into functional relationships than does an intraindustry analysis. And second, any insights gained into the causes and consequences of vertical coordination in the feeder cattle industry are not necessarily extendable beyond Ohio.

The second point is of minor concern relative to determining the applicability of the structure-conduct-performance model to vertical coordination. The first factor is more troublesome: the lack of wide variation in structural conditions and coordinating activities within one industry could lead to the discovery of no significant relationships between these variables and performance, thus causing premature rejection of the conceptual framework when its application across industries demonstrating wider variations could be productive. A cross-industry study and/or one utilizing data from a larger geographic area should reveal greater variation in structure-conduct-performance measures and thus allow more complete investigation of potential linkages.

The low explanatory power of the model regressing coordinating behavior against basic structural conditions may be due to any or some combination of these factors: (1) incomplete identification of structural variables, (2) misspecification of structural variables, (3) misspecification of the dependent variable, coordinating behavior, (4) misspecification of the functional form, or (5) lack of a more powerful relationship between structural conditions and coordinating behavior.

Because we had recognized the potential for misspecification and incomplete identification from the outset, due largely to the nature of the case examined, we consider the discovery of some significant structure-conduct relationships as a positive indication that the conceptual approach is or can be useful in aiding our understanding of the causes and consequences of various types of coordinating behavior.

Conclusion

Despite low explanatory power of the causes and consequences of vertical coordination generated by the reported use the structure-conduct-performance paradigm of industrial organization theory, we believe that there is room for

cautious optimism as to the potential usefulness of this conceptual approach. Our experiment suffered from numerous limitations of both concept and application. Conceptually, while there were previous writings detailing structural, behavioral and performance dimensions which can be logically argued as related to vertical coordination, there exists no previous report of empirical application. Thus, both the specification and measurement of such variables was largely virgin territory. Clearly, both specification and measurement need further development if this concept is to be given a fair test. Furthermore, our results may have been limited by the single industry - limited geographic area of the case examined. Broader experimentation also seems warranted.

Nonetheless, we feel some useful results emerged. Size, distance and product characteristics appear to be potentially important structural conditions affecting vertical coordination. And it appears to be operationally feasible, as well as theoretically attractive to view vertical coordination as a process, as a group of activities, and to place it on a behavioral continuum much as we place competitive behavior on a continuum. Thus, we offer a start. Much further development and experimentation will be necessary to determine how it should end.

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